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Assessment of compliance to radiation safety and protection at the radiology department

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ABSTRACT

Background: Several potential challenges with radiation protection (RP) and safety culture in radiology departments need to be addressed. This study assesses radiographers' adherence to radiation protection practices in radiology departments. ***Materials and Methods***: A cross-sectional study was conducted among radiographers; 210 self-administrated questionnaires were sent to the participants. An analysis was conducted to determine participants' adherence to radiation protection practices, including the implementation of personal protection, patient and environmental protection. The educational level of the radiographers, their years of experience and sociodemographic characteristics were assessed and compared. ***Results:*** The percentage of radiographers' adherence to practices related to environmental protection, patient protection and self-protection were 75.1%, 60.4% and 45.7%, respectively. The overall adherence to radiation protection practices score was 75.2%±18.5, where 57.4% of the radiographers exhibited good adherence, 26.9% exhibited moderate adherence and 15.7% had poor adherence. The adherence score was significantly higher among elder radiographers (P<0.0001) and more experienced ones (P=0.001). However, no significant difference in adherence score was found in relation to the radiographers' educational qualifications. ***Conclusion:*** Forty percent of the radiographers' practices proved relatively unsatisfactory in implementing radiation protection. Thus, proactive steps and corrective actions are necessary to improve radiographers' knowledge of international standards of proper radiation protection practices.

Keywords: *Radiation Protection, Radiation Safety, ALARA, Radiographers, Radiology*

INTRODUCTION

Radiation can cause damage to human tissue. The doses delivered by radiological examinations are substantially lower than the threshold needed to cause an immediate harmful effect. For example, radiation sickness, skin burn or eye damage can occur only when prolonged or repeated radiation exposure exceeds 1-2 gray (Gy) [1]. Fetus irradiation during pregnancy, when exceeding 100-200 mGy, could have adverse effects, such as mental retardation and malformation. However, even low doses can increase the probability of cancer occurrence due to changes in cell DNA [2].

Radiographers play a major role in [3,4] and are considered key to performing radiological examinations and supporting radiation exposure; Thus, their practice should always be optimized according to the ALARA principle (as

low as reasonably achievable). Producing high-quality images while keeping the patient doses as low as possible can be challenging, and therefore radiographers need to ensure total compliance with radiation protection and safety practices [5].

Radiographers must take practical steps to protect patients, staff and themselves. Patient protection from unnecessary primary and secondary radiation exposure is imperative. The gonads, thyroid, and eyes should not be the primary focus of the radiation beam if this is not necessary, and shielding must be used when applicable. Collimation, cones, and filters are essential tools to avoid unnecessary irradiation of the tissue and reduce scatter radiation. Sponge, sand bags, compression bands and other immobilization devices should be used to reduce image repetition and ensure that the patient is as comfortable as possible. Exposure parameters, such as short exposure times, geometric factors, source-to-image distance (SID), focal spot size and tube filtration, should be selected appropriately to avoid movement dullness and image blurring and to provide excellent diagnostic information. These measures support the implementation of ALARA [6].

Internationally renowned radiation safety societies and campaigns investigate radiographers' knowledge, awareness of and adherence to radiation protection safety standards, and they play an important role in the use of radiation in medical imaging. Unfortunately, such performance evaluations are often defective in most countries worldwide. Nevertheless, it must be addressed and measured to ensure that advancements in the imaging technology are concurrent with safe practices. In addition, investigating radiographers' compliance with these safety practices is considered a pivotal step in the development of future nationwide strategies for improving the situation and maintaining a safe working environment. The purpose of this study is to assess the radiation safety practices among radiographers and to identify their compliance with the international safety standards and the ALARA principle when performing radiological procedures [7–9].

MATERIALS AND METHODS

Study design, setting and period

A cross-sectional study was conducted on radiographers who had been working in government hospitals and health centres affiliated with the UAE's Ministry of Health between June and October 2017. All included radiographers were from various medical diagnostic imaging departments and had been employed for at least 1 year before participating in the study.

Data collection tool

A self-administrated questionnaire was designed after reviewing the previous literature. It was revised by a panel of consultants in the field of radiodiagnosis and occupational medicine to ensure its validity.

The first part of the questionnaire consists of demographic characteristics (age, academic qualifications and work experience). The second part investigates the participants' current radiation protection practices, in terms of minimizing radiation exposure for both the staff and the patients by, for example, using lead aprons, thyroid collars, collimation, cones, gonads shielding, proper exposure parameters and thermoluminescent dosimeters (TLD's).

A four-point Likert scale was used to score the responses: 4= always, 3=often, 2=sometimes and 1= never; the higher the score, the better the radiographer's practice. The score was transformed into a percentage by dividing the total score by the maximum possible score multiplied by 100. Accordingly, scores were categorized into: Poor adherence = <60%, Moderate adherence = 60–75% and Good adherence = 75% or more.

A pilot study was conducted on 15 randomly selected radiographers; Their results were excluded from the study. The pilot study was conducted to ensure the reliability of the questionnaire and that it could be easily understood.

All of the radiographers invited to participate

in the study (n=210) were working in the radiology department.

Ethical considerations

The research protocol was approved by the Institutional Research Unit at both the University of Sharjah and the Ministry of Health. Informed consent was obtained from all participants before conducting the study. The objectives of the study were explained to the respondents, and participants' privacy was guaranteed. The participants were informed that they were free to withdraw at any time during the data collection process.

Statistical analysis

The raw data was coded, entered into and analysed using SPSS system files (SPSS package version 20). The data was described based on frequency and distribution in the form of mean and standard deviation. The normality of the data distribution was tested using a Kolmogorov –Smirnov test, and univariate analyses were conducted using an ANOVA test. Moreover, the Bonferroni Post Hoc test was used to assess inter-groups differences. The significance of the results reached a 5% significance level.

RESULTS

Of the 210 distributed questionnaires, 197 were returned, generating a response rate of 93.8%. The participants were radiographers employed at government hospitals and were licensed to practice diagnostic radiography in the UAE. The total number of female participants was 110 (55.8%), while 100 (44.2%) were male radiographers (n=87). Table 1 describes the radiographer's demographic data in terms of age, level of education, and experience in practice. The radiographers' ages ranged between 18–65 years old, with a mean of 35±9.6 years. Approximately half of them (52.3%) held a Bachelor's degree, while less than a quarter of them had a Master's degree or PhD (19.8%). The participants' work experience ranged from 1–25 years, with a mean of 7±3.5 years.

Table 1. Socio-demographic characteristics of the studied radiographers.

Socio-demographic characteristics	Studied radiographers (n=197)	
	No.	%
Age (years)		
Less than 25	35	17.8
25-<35	76	38.6
35-<45	45	22.8
45 ≤	41	20.8
Min-Max	18.0-65.0	
Mean±SD	35.0±9.6	
Educational qualifications		
Diploma	55	27.9
Bachelors	103	52.3
Master	30	15.2
PhD	9	4.6
Duration of work experience (years)		
1-5	70	35.5
6-10	37	18.8
11-15	9	4.6
>15	81	41.1
Min-Max	1.0-25.0	
Mean±SD	7.0±3.5	

Table 2 displays the radiographers' adherence to the radiation protection measures and standards. Personal protection was assessed in terms of wearing TLD, a lead apron, and lead gloves during fluoroscopy/portable radiography and a thyroid collar while in the Operation Theatre (OT). The practices that were either neglected or never used by large proportion of the radiographers are: the use of lead gloves during fluoroscopy (37.6%), wearing a thyroid collar during OT (18.3%) and wearing TLDs (15.7%).

Regarding the practices related to patient protection, the use of proper collimation (76.2%) and the use of proper source-to-image receptor distance SID (70%.1) exhibited the highest reported adherence to radiation protection practices. However, the majority of the other radiation protection measures were neglected and insufficiently used, such as the use of the cone (32.4%) and use of the gonads shield (34.6%).

Lastly, concerning the practices related to environmental radiation protection, low adherence was found for the use of a lead apron by all co-patients and staff (60.3%), while high adherence was only noticed in regard to keeping the doors closed during the examinations (89.3%).

The scoring for participants' adherence to radiation protection practices was calculated for practices related to the protection of the radiographers themselves, patient protection and environmental protection, as seen in table 3. The highest percentage of good adherence was recorded for practices related to environmental protection (75.1%), followed by practices related to patient protection (60.4%). Surprisingly, the lowest percentage of adherence was found for practices related to the radiographers' own protection (45.7%).

The overall adherence scoring ranged from 13.3–100.0%, with a mean score of 75.2%±18.5. More than half of the radiographers (57.4%) exhibited good adherence to the protection practices, with a score of more than 75%. A lower percentage (26.9%) of radiographers exhibited moderate adherence scoring (with a score ranging between 60–75%), and only 15.7% of the studied group had poor adherence, with a score of less than 60% (table 3).

The relation between the overall adherence scores and the socio-demographic characteristics of the studied radiographers was investigated, and the results are presented in table 4. Regarding the relation between the adherence score and the age of the radiographers, it is evident that older radiographers, adhere to the personal protection practices to a greater extent; The difference observed between the studied age groups is statistically significant (P<0.0001). Indeed, higher adherence scores were found among radiographers aged 45 years or above (84.3%±16.2) compared to lower scores for younger radiographers, those aged less than 25 years (67.8%±19.9).

Similarly, work experience was also found to be correlated with a radiographer's adherence score: where a significantly higher adherence score was observed for more experienced radiographers (P=0.001). The main difference was observed between radiographers with 15 years of experience or more (80.6%±17.9) and those with only 1 to 5 years of experience (69.1%±19.1).

On the other hand, no significant difference was found regarding the adherence score in relation to the radiographers' educational qualifications, despite of the diversity of educational qualifications observed among the participants.

Table 2. Adherence to radiation protection practice among radiographers.

Practices of participants regarding radiation protection	Response of the studied radiographers (n=197)							
	Never		Sometimes		Most of time		Always	
	No.	%	No.	%	No.	%	No.	%
Personal protection								
Wearing thermoluminescent dosimeter during the work	*31*	***15.7***	13	6.6	30	15.2	123	**62.5**
Wearing lead apron during fluoroscopy	14	7.1	8	4.1	21	10.7	154	**78.1**
Wearing lead apron during portable radiography	10	5.1	28	14.2	31	15.7	128	**65.0**
Using of lead gloves during fluoroscopy	*74*	***37.6***	43	**21.8**	34	17.3	46	23.3
Wearing thyroid collar at the operating theatre	*36*	***18.3***	30	15.2	28	14.2	103	52.3
Patient protection								
Using light beam diaphragm	*20*	***10.2***	25	12.7	27	13.7	125	**63.4**
Using of the cone when needed	*48*	***24.4***	47	**23.9**	38	19.3	64	32.4
Using of proper collimation	5	2.5	11	5.6	31	15.7	150	**76.2**
Using of marker	9	4.6	22	11.2	31	15.7	135	**68.5**
Using of proper source to image receptor distance (SID)	4	2.0	11	5.6	44	22.3	138	**70.1**
Using of gonad shielding	*31*	***15.7***	55	**27.9**	43	21.8	68	34.6
Using of lead shield when applicable	8	4.1	35	17.8	41	20.8	113	57.3
Using of minimum exposure time	2	1.0	24	12.2	60	30.5	111	56.3
Protection of the environment								
Using of the lead apron for all co-patient or staff	8	4.1	34	17.3	36	18.3	119	**60.3**
Closing the room door	1	0.5	7	3.6	13	6.6	176	**89.3**

Table 3. Scoring of the adherence to radiation protection practices among the studied radiographers.

Score (%) of adherence towards personal protection		Studied radiographers (n=197)	
Practices related to radiographers' personal protection (%)	Min-Max, Mean±SD	0.0-100.0	70.1±23.5
	Poor adherence (N/%)	42	21.3%
	Moderate adherence (N/%)	65	33.0%
	Good adherence (N/%)	90	45.7%
Practices related to patient protection (%)	Min-Max, Mean±SD	0.0-100.0	75.5±20.1
	Poor adherence (N/%)	43	21.8%
	Moderate adherence (N/%)	35	17.8%
	Good adherence (N/%)	119	60.4%
Practices related to environment protection (%)	Min-Max, Mean±SD	16.7-100.0	86.6±19.2
	Poor adherence (N/%)	19	9.6%
	Moderate adherence (N/%)	30	15.2%
	Good adherence (N/%)	148	75.2%
Total score (%)	Min-Max, Mean±SD	***13.3-100.0***	***75.2±18.5***
	Poor adherence (N/%)	***31***	***15.7%***
	Moderate adherence (N/%)	***53***	***26.9%***
	Good adherence (N/%)	***113***	***57.4%***

Poor adherence: <60%, Moderate adherence: 60-<75% and Good adherence: ≥75%

Table 4. Relation between the score of adherence and radiation protection practice to the socio-demographic characteristics of the studied radiographers.

Socio-demographic characteristics	Studied radiographers		Significance
	n=197	Mean±SD	
Age (years)			
Less than 25	35	67.8±19.9	F=7.020
25-<35	76	71.8±17.5	P<0.0001*
35-<45	45	78.4±17.6	(<25,45≤)*
45≤	41	84.3±16.2	(25-<35,45≤)*
Qualifications			
Diploma	55	77.5±17.8	F=0.742
Bachelors	103	74.9±18.5	P=0.478
Master/PhD	39	72.9±19.5	
Experience (years)			
1-<5	70	69.1±19.1	F=5.695
5-<10	37	73.6±16.4	P=0.001*
10-<15	9	81.7±13.0	(1-<5, 15≤)*
15≤	81	80.6±17.9	

F?: ANOVA test, Bonferroni Post Hoc test was used for inter-groups differences *Significant at P≤0.05

DISCUSSION

To the best of our knowledge, this study is the first to be conducted in the UAE with the objective to assess radiographers' adherence to radiation protection standards. A small number of similar studies have been conducted in the region, including in Jordan [9], the Kingdom of Saudi Arabia [10], and Iran [11,12], which were used for comparison purposes.

The implementation of recommended radiation protection protocols and practices in radiology departments is vital for the safety of the radiographers, the patients and the environment [13]. The results reveal that most of the participants have moderate to low adherence to radiation protection practices. In terms of personal protection, the results are both surprising and alarming, as the radiographers should educated on and aware of the importance of using lead aprons, lead gloves and thyroid collars during their practice. Almost 60% of the radiographers stated that they had never/sometimes used lead gloves, and 33 % had never/sometimes used a thyroid collar during their practice. This is attributed to the unavailability of the thyroid collar and gloves or the radiographer's lack of knowledge about the importance of using them during the procedures; Our results in this regard are similar to those obtained in other studies [11-15].

During radiation exposure, TLDs are used to measure and monitor the occupational dose; Even slight negligence can lead to unrecorded doses [16]. The results indicate that only 63% of radiographers strictly use TLDs. Therefore, more dedicated training courses are needed and should specifically emphasise the radiation exposure risk in the workplace and stress the importance of wearing TLDs during the work.

Concerning the utilization of the patient protection tools, the study revealed that 10.2%, 24.4% and 15.7% of the participants neglected to use the light beam diaphragm, cone and gonads shielding, respectively [17,18]. Thus, it is evident that some of the participants greatly underestimate the importance of using these tools in radiation dose reduction. It is recommended to shield sensitive organs, especially the gonads and the thyroid, whenever one is near the primary beam and radiation field. Even if this represents a small risk for patients, it can be significant when considered at the population dose levels. Therefore, radiographers should establish a routine for implementing shielding practices [19,20].

Selecting the proper radiation field is important to reducing radiation doses, as this

has been proven to reduce the radiation field during spinal radiography from 8x10 to 6x6, which results in a radiation dose reduction of 50% [12]. The current study found that 76.2% of radiographers use proper collimation, which is higher than what has been determined by other studies (43.7%, 46.4% and 38.5%). Nevertheless, increased awareness is necessary to improve current practices [5,21].

Newly graduated and young radiographers exhibited less adherence to the radiation protection practices. While it was assumed that the new graduates would possess more up-to-date knowledge about radiation protection, it appears that the radiographers' adherence to the protection practices improved with higher education and work experience, which is in accordance with previous studies [22].

The ALARA concept is an essential theme in radiation protection in medicine, as its main purpose is to prevent unnecessary radiation exposure and optimize radiation doses. The three major principles of applying ALARA are: time, distance and shielding. Radiographers can effectively improve radiation protection through compliance with the established international guidelines and standards of practice and by utilizing proper tools and equipment.

CONCLUSION

The current study reveals that, currently, radiographers' practices are unsatisfactory in regard to reducing radiation exposure for patients and themselves. Thus, a systematic and harmonized approach should be initiated in the form of corrective actions to ensure that radiation protection measures and standards are properly implemented in radiology departments. Moreover, continuous education is critical for younger radiographers especially.

***Conflicts of interest*:** *Declared none.*

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